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Volumetric Analysis of Allogenic Bone Graft after Vitamin D and Calcium Administration in Sinus Lifting Procedure (Radiographic study)

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KEYWORDS

Sinus lifting, Delayed implant, Allograft, Volumetric analysis.

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ABSTRACT

Aim: The objective of this study was to assess radiographically the dimensional and volumetric changes of the grafting material after sinus lifting procedures and delayed implants placement. **Subjects and methods:** 14 patients underwent lateral sinus lifting, followed by delayed implant placement at six month after grafting. Dimensional changes were measured in the form of height involving the residual ridge and the allogenic graft immediate post-operative, at 6th month and at 12 month. Volumetric analysis of the grafting material was conducted at the following three intervals immediate after grafting, at 6 month, and 12 month postoperative. **Results:** Vit D showed significant improvement between goup A (29.24 ± 5.03) and group B (12.77 ± 2.06) and P-Value was >0.05, while calcium levels showed no statistical difference. Radiographically, no statistical difference in bone volume and height in both groups. **Conclusion:** Improvement of the vitamin D deficiency by vit D and Ca supplements not had any significant changes on the dimensional and volumetric measurements of the grafted area at the end of the study.

INTRODUCTION

Rehabilitation of edentulous posterior maxilla with dental implants poses a significant clinical challenge attributed to the inadequate bone volume caused by maxillary sinus pneumatisation and crestal bone resorption. This condition leads to an atrophic residual ridge characterized by low-density trabecular bone and a limited cortical component, complicating the implantation process and necessitating careful consideration of surgical techniques and possible augmentation strategies⁽¹⁾.

The maxillary sinus grafting technique is a common surgical technique to enhance bone volume in atrophic posterior maxilla ⁽²⁾. Sinus floor augmentation can provide the necessary the amount of bone for placement and stabilization of dental implants that essential for the initial step towards osseointegration and rehabilitation⁽³⁾.

Previous studies have demonstrated that incorporation of adjunctive agents such as growth factors, hormones, and vitamins alongside bone grafts can significantly enhance the properties of the graft material. This synergistic approach not only improves the overall regenerative outcomes but also facilitates a more favourable implant-to-bone contact, ultimately contributing to greater success in osteointegration⁽⁴⁾.

Vitamin D has a major role in regulating calcium and phosphate metabolism makes it a key player in bone remodeling and repair. It may promotes the differentiation and activity of osteoblasts and modulates of osteoclasts. Therefore, adequate levels of Vitamin D are not only essential for maintaining bone density, but also for enhancing the healing process in bone tissues affected by dental implant procedures⁽⁵⁾.

Volumetric analysis of bone graft materials is essential for evaluating their efficacy in promoting osteogenesis and ensuring optimal integration with host tissues. By quantifying the volumetric changes and assessing the material's porosity and density, researchers can establish correlations between these parameters and clinically relevant outcomes, such as bone regeneration and remodeling. Moreover, this analytical approach facilitates standardization in comparative studies of various graft materials, thereby enhancing the reproducibility and reliability of results^(6,7).

Ethical considerations and Patient Consent

The research protocol was approved by ethical committee, Faculty of Dental Medicine, Al-Azhar University, Assuit Branch. (N: AUAREC20210008-12). All details about the surgical procedure, post-operative follow up, research procedures and associated risks of procedures were explained to all patients. All patients were agreed to participate in the study and signed a consent form.

Eligibility criteria of population

Inclusion Criteria

Patients with residual bone height from 3mm: 7mm, patients with insufficient Vit D levels and patient with D4 bone density.

Exclusion Criteria

Patients that have a sufficient Ca and Vit D blood levles, sinus pathology that precludes routine sinus augmentation, heavy smokers patients more than 10 cigarettes per day and systemic diseases that interfere with bone maturation (uncontrolled diabetic patients and renal impairment).

Preoperative Evaluation

Past and present medical and dental history were taken, thorough clinical examination and radiographic evaluation (cone beam ct scan) were done to all patients to fulfill inclusion criteria in the study. Also, pre-operative serum assessment of vit D and calcium levels were performed to all patients to confirm the inclusion criteria.

Grouping

We had 14 patients of vitamin D deficiency complaining of type 4 edentuolous posterior maxilla with a residual bone height ranging from 3mm: 7mm height indicated for lateral sinus lifting. All patients were randomly divided into two groups, group (A) patients administrated Vit D and calcium supplements (300,000 IU injection form, one injection monthly for three months plus 400 IU daily in conjunction with calcium carbonate 1500mg tablet form for 6 months). While, group B not received any supplements.

Surgical procedure

The surgical procedures in this study were systematically divided into two stages: sinus lifting with allogenic bone grafting then implant placement at 6th month. In the first stage, standard



protocols for patient preparation and surgical site disinfection were strictly followed, then local anesthesia administration (Artinibsa (articine hypochloride 40mg/0.01ml + epinephrine 1:100 000)). A trapezoidal flap was then elevated, allowing for the creation of a bony window in the lateral wall of the sinus using the SLA kit (sinus lifting approach kit) (Neobiotech Co., Ltd., sauel., Republic of Korea.). Careful reflection of the sinus membrane was performed to minimize the risk of perforation. Adequate quantity of allogenic bone graft (The biopolymer Lyoplast®., Samara tissue bank, Samara State Medical University, Russia) was placed, followed by suturing of the flap using resorbable 3/0 vicryl material. At 6 months, in implant placement phase a preoperative CBCT scans to evaluate the height and volume of the grafted area before implant were done that asses the selected implant. The implant osteotomy was prepared with precision, and the implant itself (Neo **CMI Implant Co.**, *Ltd.*, *sauel.*, *Republic of Korea*) was successfully placed before final suturing with vicryl.

Post-Operative Instructions and follow up:

After each surgical procedure, all patients were instructed to follow wound care instructions, soft diet for two weeks and mouth rinsing after 24 hours with warm normal saline followed by chlorhexidine rinsing (0.2%).

Radiographic and serum analysis:

I- Radiographic evaluation:

Radiographic assessments were performed by CBCT to evaluate the vertical dimensions and volumetric changes in grafted areas in the following three intervals, immediate to grafting, at 6th month and 12 month postoperatively. Image analysis was performed with Sidexis 4 imaging system (Dentsply Sirona, Bensheim, Germany) for height measurement. Imaging data of the grafted areas were measured with 3D slicer software (version 5.8.1; developed by slicer community and supported by the National Alliance for medial image computing, USA, available at www.slicer.org).

II- Laboratory evaluation:

Serum vitamin D and calcium levels were measured preoperative and 6^{th} month postoperative.

Statistical analysis

The data were collected, tabulated, fed to the computer and statistical analyzed using IBM®SPSS statistics version 23 for Windows. using mean and standard deviation. Independent t-test to compare between two studied groups, the significance level was set at P value ≤ 0.05 .

RESULTS

Pre-operative vitamin D levels demonstrated no significant difference between the group A (mean of 12.63 ± 4.31) and the group B (mean of 13.23 ± 2.68). However, at the six-month post-operative mark, a notable disparity emerged, with the group A exhibiting a mean vitamin D level of 29.24 ± 5.03 , in contrast to the group B mean of 12.77 ± 2.06 . This indicates a significant improvement in vitamin D status in the group A following the intervention.

Analysis of the calcium levels in both groups showed no statistical significant differences between both groups either pre-operatively (the mean was 9.77 ± 0.25 in the group A and 9.54 ± 0.28 in the group B) or at 6th month post-operative (the mean was 9.95 ± 0.29 in the group A and 9.38 ± 0.3 in the group B).

Radiographic assessment of *ridge height means immediate post-operative*ly was 15.62 ± 1.11 for group A and 15.97 ± 1.11 in the group B without any significant difference (P-value was 0.6). *At 6 month* group A showed 14.07±1.21, while group B showed mean 14.5±1.78 without any significant difference (P-value was 0.68). **After 12 months** the mean was 13.75 ± 1.28 for group A and 13.97 ± 1.57

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for group B without any significant difference (P-value was 0.81).

The volumetric changes of the grafted area immediate post-operative reflect that no significant difference of both groups as the mean in the group A was 974.28 \pm 128.97mm³ and group B was 960.23 \pm 132.95. **Also, at 6 months** showed no significant difference (group A was 960.23 \pm 123.61mm³ and group B was 960.2 \pm 125.5 mm³). **At 12 months** the means were (group A was 955.69 \pm 129.71 mm³ and group B was 908.35 \pm 119.87mm³).

Table (1) The sinus graft volume at different intervals presented as an average $(\pm SD)$.

Sinus Graft Volume (SGV) Analysis					
	Group-A		Group-B		TT 4 4 C'
-	Mean	SD	Mean	SD	- 1-test Sign.
Imm- postoperative	974.28	128.97	960.23	132.95	0.827 ns
6 months postoperative	960.23	123.61	960.2	125.5	0.598 ns
12 months postoperative	955.69	129.71	908.35	119.87	0.489 ns
RM ANOVA	< 0.001***		< 0.001***		
Repeated Measure ANOVA					
Effect	P-value				
Group	0.630 ns				
Time	0.000*				
Group x Time	0.106 ns				

Significant at p<0.05, <0.01, <0.001; ns, nonsignificant at p>0.05.



Fig. (1) Screen image presented by 3D slicer showing the volumetic measurements of the grafted area in axial, coronal, sagittal and 3D views.



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DISCUSSION

Vitamin D is an essential nutrient known for its critical role in bone health, contributing to the processes of healing and remodeling. Its importance becomes particularly evident in clinical settings where patients exhibit a deficiency in this vitamin, as emerging research highlights its influence on osseointegration, process by which a dental or orthopedic implant becomes firmly anchored in bone⁽⁸⁾.

Numerous studies suggest that optimal levels of Vitamin D facilitate more effective bone healing by enhancing both the quality and quantity of bone formation surrounding implants. This superior bone integration not only supports the stability of the implant but also accelerates the overall healing process, which is crucial for patient recovery. For instance, research conducted by Fischer et al. demonstrates that, vitamin D deficiency is linked to delayed callus formation and impaired fracture healing, indicating the vitamin's integral role in these processes, although the exact mechanisms remain to be fully elucidated⁽⁹⁾.

Moreover, the correlation between low serum vitamin D levels and early implant failure has been substantiated by studies such as those conducted by Francesco Mangano et al. in 2016. Their findings underscore the necessity of maintaining adequate Vitamin D levels to optimize patient outcomes post-implantation⁽¹⁰⁾.

The use of vit D in this study was in accordance with recent researches which indicated that systemic factors, such as nutritional status, can significantly influence the process of osseointegration⁽¹¹⁾.

Another element with vit D is calcium which used in this work is essential for bone growth as it is required for impregnation of the bone matrix with minerals. A diet containing insufficient amount of calcium may lead to a low bone mineral density (BMD) that may adversely affect bone health⁽¹²⁾. Analysis of vit D and calcium were done preoperatively and at 6 months, there was enhancement of circulatory vit D in the group A after 6 months from baseline time comparable to the group B that remained stable. Enhancement of vit D levels fell within the normal levels and this improvement in the pre implant phase is in agreement with Francesco Mangano⁽¹⁰⁾. Calcium levels were similar in both groups at baseline and after 6 months only a slight, non-significant increase observed in the group A after 6 months and this attributed to the haemostatic mechanism that is responsible for stability of calcium blood levels⁽¹³⁾.

Measurement of *ridge height means immediate post-operatively* was 15.62 ± 1.11 for group A and 15.97 ± 1.11 in the group B without any significant difference (P-value was 0.6). At 6 month group A showed 14.07 ± 1.21 , while group B showed mean 14.5 ± 1.78 without any significant difference (P-value was 0.68). After 12 months the mean was 13.75 ± 1.28 for group A and 13.97 ± 1.57 for group B without any significant difference (P-value was 0.81). There was no significant difference between the two groups (P-Value>0.05).

Also, analysis of the graft volume showed that no statistical significant difference in both groups even if enhancement of the circulatory vitamin D. Immediate post-operative mean in the group A was 974.28±128.97mm³ and group B was 960.23±132.95. Also, at 6 months showed no significant difference (group A was 960.23±123.61mm³ and group B was 960.2±125.5 mm³). At 12 months the means were (group A was 955.69±129.71 mm³ and group B was 908.35±119.87mm³). These results correlate with Ulrike Schulze-Späte who reported that total bone volume and the amount of remaining graft material (% graft) were similar in both groups even with enhancement the circulatory vit D⁽¹⁴⁾. These results do not reflect the overall change in the bone, but rather indicate only a quantitative change, and it is possible that there is a change in the quality of the bone, which needs to be confirmed histologically that confirmed by Ulrike Schulze-Späte and others(14, 15).

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CONCLUSION

Improvement of the vitamin D deficiency by vit D and Ca supplements not had any significant changes on the dimensional and volumetric measurements of the grafted area at the end of the study.

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النشر الرسمي لكلية طب الأسنان جامعة الأزهر أسيوط مصر





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التحليل الحجمي لطعم عظمي خَيفي بعد إعطاء فيتامين د والكالسيوم في عملية رفع الجيوب الأنفية (دراسة شعاعية)

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الملخص :

الهدف: هدفت هذه الدراسة إلى تقييم التغيرات في أبعاد وحجم مادة التطعيم شعاعيًا بعد عمليات رفع الجيوب الأنفية ووضع الغرسات.

المواد والاساليب: خضع 14 مريضًا لرفع الجيوب الأنفية الجانبي. تلاه تأخير وضع الغرسات بعد سنة أشهر من التطعيم. تم قياس التغيرات في أبعاد المادة من حيث الارتفاع. بما في ذلك الحافة المتبقية والطعم الخيفي بعد العملية مباشرةً. وفي الشهر السادس. وفي الشهر الثاني عشر. أُجري خليل حجمي لمادة التطعيم على الفترات الثلاث التالية: مباشرة بعد التطعيم. وفي الشهر السادس. وفي الشهر الثاني عشر بعد العملية.

النتائج: أظهر فيتامين د خَسنًا ملحوظًا بين الجُموعة أ (2.04±5.03) والجُموعة ب (12.71±2.06). وكانت القيمة الاحتمالية >0.05. بينما لم تُظهر مستويات الكالسيوم أي فرق إحصائى. شعاعيًا. لم يُلاحظ أي فرق إحصائى فى حجم العظام وارتفاعها فى كلتا الجُموعتين.

الاستنتاج: لم يُحدث فّسن نقص فيتامين د بمكملات فيتامين د والكالسيوم أي تغييرات ملحوظة في القياسات البعدية والحجمية لمنطقة الطعم في نهاية الدراسة.

الكلمات المفتاحية: رفع الجيوب الأنفية، الزراعة المتأخرة، الطعم الخيفي، والتحليل الحجمي